(Abstract)

IMAGE ENHANCEMENT IN LINEAR, COHERENT OPTICAL SYSTEMS

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A linear, coherent optical system in its most elementary form has its basis in a point source located in the focal plane of a collimating lens. This collimator illuminates an object transparency with a plane wave (coherently). A second lens collects this light and brings it to a focus, forming a Fraunhofer diffraction pattern. The diffraction pattern constitutes a spatial frequency analysis of the object. A subsequent set of lenses transforms the diffraction pattern into an image. The system is linear, from object to image, in light amplitude.

Such a system provides a unique means for image enhancement in that these spatial frequencies are displayed, in amplitude and phase, in a particular plane within the optical system. By inserting "filters" of various configurations and transmissive properties into this plane, the quality and makeup of the image may be controlled. Thus, it is entirely possible to attenuate those frequencies which contribute to the gross characteristics of the object transparency while passing, untouched, those which contribute to the high-frequency detail. This operation provides an improvement in edge sharpness and image contrast, and is the basic principle behind image enhancement.

Since filtering is the basis of enhancement, the filters are probably the most important single item in the system. There are three basic filter types; 1) sharp cutoff, occluding, 2) frequency attenuating, and 3) frequency matching. The first is useful for mensuration, as it destroys image tone and improves contrast in the vicinity of an edge. By using a two-step photographic process, such filters may be used for enhancement. The second is especially suited for enhancement and performance of optimum filtering, since the transmissive properties are continuous, can assume a wide variety of cross sections, and do not sharply cut off. It is with this type of filter that spatial filtering should achieve its greatest usefulness. The third type is useful for obtaining relative improvement of one subject within an object transparency over its general background.

These concepts have been embodied in a scientific instrument, the Image Enhancement Viewer. It is a linear, coherent optical system which has been mechanized to perform spatial filtering operations in a rapid and efficient manner and to facilitate the enhancement of optical images. The instrument, at present, uses sharp cutoff, occluding filters exclusively. These filters are positioned automatically in the optical path, at the control of the operator who can simultaneously observe the consequent effects on the image. Object transparencies are immersed in a fluid gate to minimize the effects of emulsion scratches and other coherence-destroying irregularities. The system is capable of wide adjustment (for additional or different optical elements) and can mount many filter types.